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An Annotated Bibliography of Attempts to Rear the Larvae of Marine Fishes in the Laboratory

ROBERT C. MAY

SEATTLE, WA.
August 1971

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597. Fur seal investigations, 1967. By Bureau of Commercial Fisheries Marine Mammal Biological Laboratory. March 1970, vii + 104 pp., 31 figs., 79 tables.

599 Diagnostic characters of juveniles of the shrimps *Penaeus aztecus aztecus, P. duorarum duorarum,* and *P. brasiliensis* (Crustacea, Decapoda, Penaeidae). By Isabel Perez Farfante. February 1970, iii + 26 pp., 25 figs.

600. Birectilinear recruitment curves to assess influence of lake size on survival of sockeye salmon (*Oncorhynchus nerka*) to Bristol Bay and forecast runs. By Ralph P. Silliman. March 1970, iii + 9 pp., 13 figs., 2 tables.

601. Effect of flow on performance and behavior of chinook salmon in fishways. By Clark S. Thompson. March 1970, iii + 11 pp., 8 figs., 3 tables.

602. Biological characteristics of intertidal and freshwater spawning pink salmon at Olsen Creek, Prince William Sound, Alaska, 1962-63. By John H. Helle. May 1970, iii + 19 pp., 11 figs., 5 tables.

603. Distribution and abundance of fish in the Yakima River, Wash., April 1957 to May 1958. By Benjamin G. Patten, Richard B. Thompson, and William D. Gronlund. June 1970, iii + 31 pp., 26 figs., 37 tables.

604. The flora and fauna of a basin in central Florida Bay. By J. Harold Hudson, Donald M. Allen, and T. J. Costello. May 1970, iii + 14 pp., 2 figs., 1 table.

605. Contributions to the life histories of several penaeid shrimps (Penaeidae) along the south Atlantic Coast of the United States. By William W. Anderson. May 1970, iii + 24 pp., 15 figs., 12 tables.

606. Annotated references on the Pacific saury, *Cololabis saira*. By Steven E. Hughes. June 1970, iii + 12 pp.

607. Studies on continuous transmission frequency modulated sonar. Edited by Frank J. Hester. June 1970, iii + 26 pp. 1st paper, Sonar target classification experiments with a continuous-transmission Doppler sonar, by Frank J. Hester, pp. 1-20, 14 figs., 4 tables; 2d paper, Acoustic target strength of several species of fish, by H. W. Volberg, pp. 21-26, 10 figs.

608. Preliminary designs of traveling screens to collect juvenile fish. July 1970, v + 15 pp. 1st paper, Traveling screens for collection of juvenile

Continued on inside back cover.

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An Annotated Bibliography of Attempts to Rear the Larvae of Marine Fishes in the Laboratory

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ABSTRACT

A bibliography has been compiled of papers which describe attempts to rear the larvae of marine fishes in the laboratory, covering the period 1878 to 1969. Annotations summarize each paper, and appendixes list the species of fishes studied and the types of food used in the attempts to rear them.

INTRODUCTION

The past few years have seen a resurgence of interest in rearing marine fishes under laboratory conditions. The literature pertaining to this subject, however, is widely scattered and in some cases relatively inaccessible. The present annotated bibliography was prepared as an aid to researchers desiring a source of references to, and quick summary of, previous attempts to rear the larvae of marine fishes in the laboratory.[1] It includes all papers which have been found, after an extended search of the literature, describing attempts to rear larval marine fishes under laboratory conditions, from 1878 through 1969. Certain papers (mostly recent ones concerned with larval behavior and physiology), whose rearing methods are described in greater detail by the same authors in other papers, are excluded.

Appendix I lists by families all fish species studied in the papers included in the bibliography. Since the choice of a suitable larval food appears to be one of the most important prerequisites for successful rearing, Appendix II lists the types of food whose use is described in these papers. Appendix II is taken, with a few additions, from May (California Cooperative Oceanic Fisheries Investigations Reports 14: 76-83, 1970), where detailed discussions of the different food types will be found.

For each paper, annotations are given under as many of the following headings as the information supplied by the original author permits.

FISH STUDIED: The currently accepted genus, species, author and family of the fish are given.

FOODS: (+) indicates that the preceding food was taken by the larvae, (—) indicates that the food was not taken, and (?) indicates that the author does not say whether the food was taken.

CONTAINERS: The volume and material, and occasionally the shape, of the rearing containers are given, and if circulating or periodically

[1] The bibliography was originally assembled for the benefit of workers at the Bureau of Commercial Fisheries (now National Marine Fisheries Service) Fishery-Oceanography Center in La Jolla, where an extensive program of research on larval fishes has developed. The author was supported by a Bureau of Commercial Fisheries Predoctoral Fellowship during the preparation of this manuscript.

renewed rather than static water was used, this is noted.

TEMPERATURE: The temperature or range of temperatures to which larvae were exposed during rearing is given; temperatures separated by commas or by the word *and* indicate that separate rearing attempts were carried out at different temperatures.

MAXIMUM TIME KEPT: Unless otherwise noted, this refers to the maximum time the larvae were kept alive after hatching. The values given under this heading may have different meanings in different papers, since in some cases the experiments ended due to death of all the larvae while in others the experiments were terminated purposely by the experimenters, and occasionally it is impossible to tell from the reports whether they were terminated purposely or not. For further information on this point, the original papers must be consulted.

MAXIMUM LENGTH REACHED: The length at the maximum time that larvae were kept is given, unless otherwise noted. The range of lengths attained is given where possible. TL denotes total length, SL standard length (i.e., measured to the tip of the notochord), and the absence of TL or SL indicates that the author does not state how the lengths were measured.

SURVIVAL: The percentage of hatched larvae surviving a specified length of time, or past a specified stage, is given. If not otherwise noted, the survival value refers to the percentage of larvae alive at the end of the experiment as indicated under MAXIMUM TIME KEPT.

REMARKS: These are self-explanatory.

BIBLIOGRAPHY

ANTHONY, R. The cultivation of the turbot.
1910. Proceedings of the 4th International Fishery Congress, Washington, 1908, Pt. 2, Bull. U.S. Bur. Fish. 28: 861-870. (Translation.)

FISH STUDIED: *Scophthalmus maximus* (L.), Bothidae.
FOOD: Wild plankton (+).
CONTAINERS: 50-liter glass jars with rotating discs, part of water renewed daily.
TEMPERATURE: 18°-20° C.
MAXIMUM TIME KEPT: 20 days + (?).
SURVIVAL: 90% passed yolk absorption.

BARDACH, JOHN E. The status and potential of aquaculture, particularly fish culture. Vol. 2, Part III, Fish Culture. Amer. Inst. Biol. Sci., Wash., D.C. 225 p. [P. 22-29 of this work describe the rearing experiments of G. O. Schumann.]
1968.

FISH STUDIED: *Scomber japonicus* Houttuyn, Scombridae.
FOODS: Wild plankton (+); *Artemia* nauplii given to older larvae.
CONTAINERS: 19,000 liters (500 gal).
MAXIMUM TIME KEPT: 6 months +.
MAXIMUM LENGTH REACHED: 200 mm fork length at 6 months.
REMARKS: Food was collected at night with a submersible pump and a light to attract plankton. More than 20 other species of fishes were reared using these methods, but detailed descriptions of the work are not available.

BISHAI, H. M. Rearing fish larvae.
1961. Bull. Zool. Soc. Egypt 16: 4-29.

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOODS: *Artemia* nauplii (+), *Tigriopus fulvus* nauplii (+), copepods (?), phytoplankton ("*Chlamydomonas, Nitzschia,* etc.") (+), liver of shore crab (*Carcinus maenas*) (?); rearing aquaria prepared by stocking with *Artemia, Tigriopus* and "other copepods," and attached algae; food introduced from a "food supply tank" containing algae and copepods including *Tigriopus.*
CONTAINERS: 64-liter, concrete; water filtered, and renewed every 3 days; various other containers used in some experiments.
TEMPERATURE: 13°-15° C.
MAXIMUM TIME KEPT: 21 days.
MAXIMUM SIZE REACHED: 12 mm.
SURVIVAL: 0.
REMARKS: Not kept beyond "critical stage" on phytoplankton alone.

BLAXTER, J. H. S. 1962. Herring rearing—IV. Rearing beyond the yolk-sac stage. Mar. Res. Scot. 1962 (1): 18 p.

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOODS: Commercial fish fry food (?); *Asterias* eggs (?); cultures of *Chlamydomonas* (?), *Nitzschia* (?), *Dunaliella* (?), *Chlorella* (?), and *Skeletonema* (?); *Artemia* nauplii (+); *Balanus nauplii* (+); *Tigriopus* "young stages" (?); *Tisbe* (?); *Anguillicula* (?).
CONTAINERS: 50-liter glass (painted black) or "perspex"; 2000-liter fiberglass; circulating water.
TEMPERATURE: 7°-8° and 11° C.
MAXIMUM TIME KEPT: 78 days at 7°-8° C, 91 days at 11° C.
MAXIMUM LENGTH REACHED: 33 mm.
SURVIVAL: ca. 50% passed yolk-absorption, none reached metamorphosis.
REMARKS: "No real success" with any food except *Balanus* nauplii; *Artemia* nauplii were given from day 40-50 on, due to unavailability of *Balanus* nauplii.

BLAXTER, J. H. S. 1968. Rearing herring larvae to metamorphosis and beyond. J. Mar. Biol. Ass. U.K. 48: 17-28.

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOODS: *Balanus* nauplii (+) and wild plankton (+), *Artemia* nauplii (+) when plankton scarce; *Artemia* alone (+); *Tigriopus fulvus* (+) and other foods given to advanced larvae.
CONTAINERS: 200-liter black "Darvic"; 1500-liter fiberglass for older larvae; circulating water in most experiments, "semi-static" water in some (i.e., 20 liters renewed daily in each 200-liter tank).
TEMPERATURE: 7°-14° C.
MAXIMUM TIME KEPT: 182 days on wild plankton plus *Balanus* nauplii.
MAXIMUM LENGTH REACHED: 25 mm on *Artemia* alone, 44-77 mm on wild plankton plus *Balanus* nauplii.
SURVIVAL: On wild plankton plus *Balanus* nauplii: 25-35% through yolk-absorption, 1-4% through metamorphosis; on *Artemia* alone: 16-28% through yolk-absorption, none past metamorphosis.
REMARKS: Natural plankton was used when *Balanus* nauplii no longer available.

BLAXTER, J. H. S. 1969. Experimental rearing of pilchard larvae, *Sardina pilchardus*. J. Mar. Biol. Ass. U.K. 49: 557-575.

FISH STUDIED: *Sardina pilchardus* (Walbaum), Clupeidae.
FOODS: Wild plankton, from both inshore and offshore collections (+); cultures of *Chlamydomonas* sp. (+), *Dunaliella primolecta* (+), *Olisthodiscus* sp. (+), *Cryptomonas maculata* (+), *Halosphaera minor* (+), *Prorocentrum micans* (+), *Ditylum brightwellii* (+), *Lauderia borealis* (+).
CONTAINERS: 25-liter circular black plastic, 10 liters renewed daily; phytoplankton fed to larvae in 1-liter beakers.
TEMPERATURE: 13.9°-18.8° C.
MAXIMUM TIME KEPT: 10 months.
MAXIMUM LENGTH REACHED: 52 mm.
SURVIVAL: 12% alive 2 weeks after yolk absorption, at 15.8°-16.3° C using offshore plankton.
REMARKS: Larvae feeding on phytoplankton survived no longer than starved controls.

BLAXTER, J. H. S., and G. HEMPEL. 1961. Biologische Beobachtungen bei der Aufzucht von Heringsbrut. Helgolaender wiss. Meeresunters. 7: 260-284. [English summary.]

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOODS: Wild plankton (+); *Artemia* nauplii (+); wild plankton plus *Artemia* nauplii (+); wild plankton plus *Mytilus* trochophores (?).
CONTAINERS: 120-liter earthenware, either continuous circulation or 30 liters renewed every 2 days.
TEMPERATURE: 7°-15° C.
MAXIMUM TIME KEPT: 4 months, on wild plankton plus *Artemia* nauplii.
MAXIMUM LENGTH REACHED: 20-39 mm TL on wild plankton plus *Artemia* nauplii; 20 mm TL on *Artemia* nauplii alone.
SURVIVAL: 0.3% passed metamorphosis on wild plankton plus *Artemia* nauplii.

BÜCKMAN, ADOLF, WILHELM HARDER, and GOTTHILF HEMPEL. 1953. Unsere Beobachtungen am Hering, *Clupea harengus* L. Kurz. Mitt. fischereibiol. Abt. Max-Plank Inst. Meeresbiol. 3: 22-42. [English summary.]

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOODS: Copepods (+), *Daphnia* (+), egg yolk (+).
CONTAINERS: Various.
REMARKS: This paper comprises mainly behavioral observations on advanced larvae. *Daphnia* were taken only when moving in the manner of copepods, egg yolk only when tossed about by water turbulence.

BUDD, PAUL L. 1940. Development of the eggs and larvae of six California fishes. Calif. Dep. Fish Game, Fish Bull. 56, 50 p.

FISHES STUDIED: *Parophrys vetulus* Girard, *Pleuronichthys verticalis* Jordan and Gilbert, *Pleuronichthys decurrens* Jordan and Gilbert, *Pleuronichthys coenosus* Girard, Pleuronectidae; *Atredius lateralis* (Girard), *Clinocottus analis* (Girard), Cottidae.
FOODS: Wild plankton (?); *Nitzschia* (?); *Dunaliella* (?); "freshly hatched larvae" of *Strongylocentrotus purpuratus* (?), *Artemia salina* (?), and *Tigriopus fulvus* (?).
CONTAINERS: 3.8-liter jars with rotating celluloid discs.
REMARKS: All larvae died during "critical period," apparently through starvation.

CHIRINOS de VILDOSO, AURORA, and ESMERALDA CHUMAN. 1964. Notes sobre el desarollo de huevos y larvas del pejerrey *Odontesthes* (*Austromenidia*) *regia regia* (Humboldt). Bol. Inst. Mar Peru 1: 3-31. [English summary.]

FISH STUDIED: *Odontesthes* (*Austromenidia*) *regia regia* (Humboldt), Atherinidae.
FOOD: *Artemia* nauplii (+).
CONTAINERS: 6-liter jars.
TEMPERATURE: 20° C.
MAXIMUM TIME KEPT: 42 days.
MAXIMUM LENGTH REACHED: 18 mm TL.

CUNNINGHAM, J. T. 1893-95a. The life-history of the pilchard. J. Mar. Biol. Ass. U.K. 3: 148-153.

FISH STUDIED: *Sardina pilchardus* (Walbaum), Clupeidae.
FOODS: Minced worms (+) and wild plankton (+).
TEMPERATURE: 17° C.
MAXIMUM TIME KEPT: 10 days.
MAXIMUM LENGTH REACHED: 5.5 mm.
SURVIVAL: 0.

CUNNINGHAM, J. T. 1893-95b. Experiments on the rearing of fish larvae in the season of 1894. J. Mar. Biol. Ass. U.K. 3: 206-207.

FISHES STUDIED: *Gadus merlangus* L., Gadidae; *Pleuronectes platessa* L., Pleuronectidae.
FOODS: *Nereis* eggs (*G. merlangus* —, *P. platessa* +), wild plankton (+).
CONTAINER: "Small tank," circulating water.
TEMPERATURE: 12° C.
MAXIMUM TIME KEPT: *G. merlangus* 11 days, *P. platessa* 37 days.
REMARKS: *P. platessa* took *Nereis* eggs more readily than wild plankton.

DANNEVIG, ALF. 1948. Rearing experiments at the Flødevigen seafish hatchery 1943-1947. J. Cons. 15: 277-283.

FISHES STUDIED: *Clupea harengus* L., Clupeidae; *Scomber scombrus* L., Scombridae; *Microstomus kitt* (Walbaum), Pleuronectidae; *Solea solea* (L.), Soleidae.
FOODS: *Ostrea edulis* larvae (+), wild plankton plus *Artemia* nauplii (+), *Pomatoceros* sp. (?), *Balanus* nauplii (?), "raw cultures of phytoplankton" (?), "cultures of single species of green algae and naked flagellates" (?).
CONTAINERS: 35-liter glazed earthenware pipes, circulating water.
SURVIVAL: Feeding *Ostrea* larvae to smaller fish larvae, *Artemia* nauplii and wild plankton to larger larvae: 21% of herring survived to "size large enough for vertebrae to be counted"; soles reared "with no appreciable mortality."

REMARKS: Phytoplankton gave "no positive results."

DANNEVIG, ALF, and SIGFRED HANSEN. 1952. Faktorer av betydning for fiskeegenes og fiskeyngelens oppvekst. Fiskeridir. Skr., Ser. Havunders. 10(1): 36 p. [English summary; English translation of p. 6-16, the section on herring: Translation No. 415, Marine Laboratory, Aberdeen, Scotland.]

FISHES STUDIED: *Clupea harengus* L., Clupeidae; *Gadus morhua* L., Gadidae; *Pleuronectes platessa* L., Pleuronectidae; "other flatfishes."
FOODS: *Artemia* nauplii plus wild plankton (+).
CONTAINERS: 35-liter glazed earthenware pipes, circulating water.
MAXIMUM TIME KEPT: Past metamorphosis.

DANNEVIG, HARALD. 1897. On the rearing of the larval and post-larval stages of the plaice and other flatfishes. Rep. Fish. Bd. Scot. 1896, Pt. 3: 175-193, pl. IV.

FISH STUDIED: *Pleuronectes platessa* L., Pleuronectidae.
FOOD: Wild plankton (+).
CONTAINER: 50-liter glass carboy, water renewed once or twice daily.
MAXIMUM TIME KEPT: Past metamorphosis.
MAXIMUM LENGTH REACHED: 13.76 mm TL on day 45.

DAVID, LORE R. 1939. Embryonic and early larval stages of the grunion, *Leuresthes tenuis*, and of the sculpin, *Scorpaena guttata*. Copeia 1939: 75-81.

FISH STUDIED: *Leuresthes tenuis* (Ayres), Atherinidae.
FOODS: Wild plankton (+), cultured diatoms (species not given) (+).
TEMPERATURE: 18° C (?).
MAXIMUM TIME KEPT: ca. 2 weeks.
MAXIMUM LENGTH REACHED: ca. 9 mm.
REMARKS: Found *Rhizosolenia*, *Chaetoceros*, and "small crustaceans" in larval guts. No attempt to rear *Scorpaena* is described.

DELMONTE, PETER J., IRA RUBINOFF, 1968. and ROBERTA W. RUBINOFF. Laboratory rearing through metamorphosis of some Panamanian gobies. Copeia 1968: 411-412.

FISH STUDIED: *Lophyogobius cyprinoides* (Pallas), Gobiidae.
FOODS: Commercial fish fry foods (+), cultured *Dunaliella* (?), *Artemia* nauplii (+), attached filamentous algae (+) and zooplankton (+) growing in rearing containers.
CONTAINERS: Plastic wading pools, 320-570 liters (85-150 gal).
TEMPERATURE: 24°-29° C.
MAXIMUM TIME KEPT: 153 days.
MAXIMUM LENGTH REACHED: 32 mm.
SURVIVAL: ca. 15% (presumably, past metamorphosis).
REMARKS: Brief mention is also made of the rearing of three specimens of *Bathygobius andrei* (Sauvage) through metamorphosis.

DEUEL, DAVID G., JOHN R. CLARK, and 1966. A. J. MANSUETI. Description of embryonic and early larval stages of bluefish, *Pomatomus saltatrix*. Trans. Amer. Fish. Soc. 95: 264-271.

FISH STUDIED: *Pomatomus saltatrix* (L.), Pomatomidae.
FOOD: Fertilized *Arbacia* eggs (?).
CONTAINERS: Aquaria of 19, 38, and 76 liters (5, 10, and 20 gal).
TEMPERATURE: 18°-22° C.
MAXIMUM TIME KEPT: 7 days.
SURVIVAL: 0.
REMARKS: Behavior indicated that larvae may have taken the food.

DÔTU, YOSIE, and SATOSHI MITO. 1958. The bionomics and life history of the gobioid fish, *Luciogobius sakaiensis* Dôtu. Sci. Bull. Fac. Agr. Kyushu Univ. 16: 419-425. [In Japanese, with English summary.]

DÔTU and MITO—Cont.

FISH STUDIED: *Luciogobius sakaiensis* Dôtu, Gobiidae.

FOODS: Copepods from wild plankton (+).

CONTAINER: Glass jar.

MAXIMUM TIME KEPT: 32 days.

MAXIMUM LENGTH REACHED: 12.2 mm TL.

FABRE-DOMERGUE, and EUGÈNE

1897. BIÉTRIX. Recherches biologiques applicables à la pisciculture maritime sur les oeufs et les larves des poissons de mer et sur le turbot. Ann. Sci. Nat. (Zool.). 8 Sér., Tome 4: 151-220.

FISHES STUDIED: *Clupea harengus* L., *Alosa* sp., Clupeidae; *Taurulus bubalis* (Euphrasen), Cottidae; *Trachinus* sp., Trachinidae; *Scomber scombrus* L., Scombridae; *Atherina presbyter* Valenciennes, Atherinidae.

FOODS: Powdered cooked egg yolk (—); crushed mussel (—); wild plankton (+); "algae" (—); cultured infusorians (mainly *Euplotes*) (—); dissociated elements of a filamentous brown diatom and of a blue-green alga (—); *Philaster digitiformis* (—); Ascidian larvae (—).

CONTAINERS: Crystallizing dishes, water renewed frequently.

TEMPERATURE: Various, within the range 6°-17° C.

MAXIMUM TIME KEPT: *T. bubalis* 22 days, *A. presbyter* 16 days, *S. scombrus* 9 days, *Alosa* 7 days, *Trachinus* 6 days, *C. harengus* 4 days.

MAXIMUM LENGTH REACHED: *A. presbyter* 8 mm, *Alosa* 5.4 mm.

SURVIVAL: 0.

FABRE-DOMERGUE, and EUGÈNE

1905. BIÉTRIX. Développement de la Sole (*Solea vulgaris*). Introduction à l'étude de la pisciculture marine. Travail du Laboratoire de Zoologie Maritime de Concarneau. Vuibert et Nony, Paris. 243 p.

FISH STUDIED: *Solea solea* (L.), Soleidae; brief references to rearing of other species.

FOODS: *Dunaliella salina* (+), wild plankton with larval fishes (+).

CONTAINERS: 50-liter glass jars with rotating discs; crystallizing dishes.

MAXIMUM TIME KEPT: 8 months.

MAXIMUM LENGTH REACHED: 55-76 mm.

REMARKS: *Dunaliella* was collected from salt marshes and cultured in the laboratory. Larvae fed first on *Dunaliella,* but soon became carnivorous and preyed upon other larval fishes (particularly sprat larvae, *Sprattus sprattus* (L.)). Larvae lived only 8 days in crystallizing dishes but passed metamorphosis in large jars with rotating discs. In an earlier paper (C. R. Acad. Sci. Paris, 132: 1136-1138, 1901) these authors give a survival value of 50% for sole larvae feeding on *Dunaliella* and wild plankton containing larval fishes.

FAHEY, WILLIAM E. A temperature con-
1964. trolled salt-water circulating apparatus for developing fish eggs and larvae. J. Cons. 28: 364-384.

FISH STUDIED: *Alosa pseudoharengus* (Wilson), Clupeidae; *Fundulus majalis* (Walbaum), Cyprinodontidae; *Bairdiella chrysura* (Lacépède), Sciaenidae; *Mugil cephalus* L., Mugilidae.

FOODS: *Artemia* nauplii (+), first and second naupliar stages of *Tigriopus californicus* (+).

CONTAINERS: 4-liter polyethylene, water forced in and out of mesh-covered window on bottom.

TEMPERATURE: 19.0°, 23.0°, and 27.0° C.

MAXIMUM TIME KEPT: *Fundulus* 79 days.

SURVIVAL: *Fundulus* 92-98%.

REMARKS: *Fundulus* was fed *Artemia* nauplii, other species fed *Tigriopus* nauplii; results of rearing are given only for *Fundulus. Tigriopus* nauplii were reared in mass culture.

FISHELSON, L. Observations on littoral fish-
1963. es of Israel. II. Larval development and metamorphosis of *Blennius pavo* Risso (Teleostei, Blenniidae). Israel J. Zool. 12: 81-91.

FISH STUDIED: *Blennius pavo* Risso, Blenniidae.

FOODS: Cooked egg yolk (+), small copepods (+), *Artemia* nauplii (+).

TEMPERATURE: 23°-25° C.
MAXIMUM TIME KEPT: 27 days +.
MAXIMUM LENGTH REACHED: 11.4 mm SL.

FLÜCHTER, JÜRGEN. Versuche zur Brut-
1965. aufzucht der Seezunge *Solea solea* in kleinen Aquarien. Helgolaender wiss. Meeresunters. 12: 395-403. [English summary.]

FISH STUDIED: *Solea solea* (L.), Soleidae.
FOOD: *Artemia* nauplii (+).
CONTAINER: 30-liter glass aquarium.
TEMPERATURE: 15°-18° C.
MAXIMUM TIME KEPT: 6 months.
MAXIMUM LENGTH REACHED: 70-82 mm TL.
SURVIVAL: 80% passed metamorphosis.
REMARKS: Growth was comparable to growth in nature.

FORRESTER, C. R. Laboratory observations
1964. on embryonic development and larvae of the Pacific cod (*Gadus macrocephalus* Tilesius). J. Fish. Res. Bd. Can. 21: 9-16.

FISH STUDIED: *Gadus macrocephalus* Tilesius, Gadidae.
FOODS: *Artemia* nauplii (?), *Skeletonema costatum* (?), *Monochrysis lutheri* (?).
TEMPERATURE: 5°-11° C.
SURVIVAL: 0.

FUJITA, SHIRO. On the larval stages of a
1957. scorpaenid fish, *Sebastes pachycephalus nigricans* (Schmidt). Jap. J. Ichthyol. 6: 91-93. [In Japanese, with English summary.]

FISH STUDIED: *Sebastes pachycephalus nigricans* (Schmidt), Scorpaenidae.
FOOD: *Artemia* nauplii (+).
CONTAINER: Glass jar.
MAXIMUM TIME KEPT: 28 days (i.e., past metamorphosis).

FUJITA, SHIRO. On the egg development
1958. and larval stages of a viviparous scorpaenid fish, *Sebastes oblongus* Günther. Bull. Jap. Soc. Sci. Fish. 24: 475-479. [In Japanese, with English summary.]

FISH STUDIED: *Sebastes oblongus* Günther, Scorpaenidae.
FOOD: *Artemia* nauplii (+).
CONTAINER: Glass jar.
MAXIMUM TIME KEPT: Approximately 1 month.
MAXIMUM LENGTH REACHED: 12-14 mm TL.

FUJITA, SHIRO. Early development and
1965. rearing of two common flatfishes, *Eopsetta grigorjewi* (Herzenstein) and *Tanakius kitaharai* (Jordan et Starks). Bull. Jap. Soc. Sci. Fish. 31: 258-262. [In Japanese, with English summary.]

FISHES STUDIED: *Eopsetta grigorjewi* (Herzenstein), *Tanakius kitaharai* (Jordan and Starks), Pleuronectidae.
FOODS: Fertilized sea urchin eggs (?) and *Artemia* nauplii (+).
CONTAINER: Glass jar.
TEMPERATURE: 11.0°-13.8° C.
MAXIMUM TIME KEPT: *E. grigorjewi* 12 days, *T. kitaharai* 29 days +.
MAXIMUM LENGTH REACHED: *T. kitaharai* 7.5 mm TL on day 29.

FUJITA, SHIRO. Egg development, larval
1966. stages, and rearing of the puffer, *Lagocephalus lunaris spadiceus* (Richardson). Jap. J. Ichthyol. 13: 162-168. [In Japanese, with English summary.]

FISH STUDIED: *Lagocephalus lunaris spadiceus* (Richardson), Tetraodontidae.
FOODS: Boiled egg yolk (+) and *Artemia* nauplii (+).
TEMPERATURE: 21.7°-24.5° C.
MAXIMUM TIME KEPT: 36 days + (i.e., past metamorphosis).
MAXIMUM LENGTH REACHED: 6.6 mm TL at 21-36 days.

FUJITA, SHIRO, and KEITARO UCHIDA.
1959. Breeding habits and rearing of larvae of a blennoid fish, *Ernogrammus hexagrammus* (Temminck et Schlegel).

FUJITA and UCHIDA—Cont.

Sci. Bull. Fac. Agr. Kyushu Univ. 17: 283-289. [In Japanese, with English summary.]

FISH STUDIED: *Ernogrammus hexagrammus* (Temminck and Schlegel), Stichaeidae.
FOOD: *Artemia* nauplii (+).
CONTAINER: Glass jar.
MAXIMUM TIME KEPT: 34 days (i.e., past metamorphosis).
MAXIMUM LENGTH REACHED: 13 mm TL.

GARSTANG, WALTER. Preliminary experi-
1900. ments on the rearing of sea-fish larvae. J. Mar. Biol. Ass. U.K. 6: 70-93.

FISH STUDIED: *Blennius ocellaris* L., Blenniidae.
FOOD: Wild plankton (+).
CONTAINER: 13-liter plunger jar.
TEMPERATURE: 18.8°-19.2° C.
MAXIMUM TIME KEPT: 13-14 weeks (i.e., past metamorphosis).
MAXIMUM LENGTH REACHED: 19-25.5 mm TL.
SURVIVAL: 20% at 52 days.
REMARKS: Polychaetes were given to advanced (ca. 20 mm) larvae.

GROSS, F. Notes on the culture of some ma-
1937. rine plankton organisms. J. Mar. Biol. Ass. U.K. 21: 753-768.

FISHES STUDIED: *Clupea harengus* L., Clupeidae; *Lophius piscatorius* L., Lophiidae; *Sardina pilchardus* (Walbaum), Clupeidae.
FOODS: *Chlamydomonas* sp. (+), *Prorocentrum micans* (+), *Thalassiosira* sp. (+), *Coscinodiscus radiatus* (—), *Skeletonema costatum* (—), *Artemia* nauplii (+), wild plankton (—).
CONTAINERS: Fingerbowls and "small tanks."
TEMPERATURE: 8°-17° C.
MAXIMUM TIME KEPT: *C. harengus* 27 days, *L. piscatorius* 29 days, *S. pilchardus* 15 days.
SURVIVAL: 30% of the *L. piscatorius* were alive after 20 days.
REMARKS: *L. piscatorius* ate only *Artemia* nauplii; other fishes were offered only phytoplankton. Author attributes death of larvae to lack of temperature control.

HERTLING, HELMUTH. Die Züchtung von
1932. Meeresfischen für wissenschaftliche und praktische Zwecke. *In* E. Abderhalden (ed.), Handbuch der biologische Arbeitsmethoden. Abt. 9, Teil 6, Heft 2: 195-366.

FISH STUDIED: *Agonus cataphractus* L., Agonidae.
FOODS: *Coscinodiscus concinnus* (+), *Biddulphia mobiliensis* (+), copepods (+).
MAXIMUM TIME KEPT: Past metamorphosis.
REMARKS: This paper reviews in detail much of the rearing work done prior to the 1930's and also includes a few apparently original observations; the rearing of *Agonus* is the only original work for which information on feeding is given.

HEUTS, M. J. Experimental studies on adap-
1947. tive evolution in *Gasterosteus aculeatus* L. Evolution 1: 89-102.

FISH STUDIED: *Gasterosteus aculeatus* L., Gasterosteidae.
FOODS: Powdered eggs (+); aquaria contained "a rich microfauna and flora."
CONTAINERS: "Large aquaria."
TEMPERATURE: Various, within the range 10°-23° C.
MAXIMUM TIME KEPT: 1 year +.
REMARKS: The author states that the "rich microfauna and flora" in the aquaria is "necessary for successful rearing of the offspring."

HIRANO, REIJIRO. Rearing of black sea
1969. bream larva. Symposium on Culture and Propagation of Sea Breams. Bull. Jap. Soc. Sci. Fish. 35: 567-569, 603-604. [In Japanese, with English summary.]

FISH STUDIED: *Mylio macrocephalus* (Basilewsky), Sparidae.
FOODS: *Crassostrea gigas* larvae (+), *Brachionus plicatilis* (+), *Balanus amphitrite albicostatus* nauplii (+), *Artemia* nauplii (+).

IVANCHENKO, L. A., and O. F. IVANCHEN-
1969. KO. Transition to active feeding by

larval and juvenile white sea herring (*Clupea pallasii* Natio *Maris-albi* Berg) in artificial conditions. Dokl. Biol. Sci. 184: 207-209. (Translated from Dokl. Akad. Nauk S.S.S.R. 184: 1444-1446.)

FISH STUDIED: *Clupea pallasii* Valenciennes, Clupeidae.
FOODS: Wild plankton (+); homogenates of *Mytilus* (+), periwinkle (—), *Fucus* (—), and kelp (—); phytoplankton (+); cooked egg yolk (+); cooked egg yolk plus wild plankton (+).
CONTAINERS: "Aquarium" and crystallizing dishes.
TEMPERATURE: 7°-19° C.
MAXIMUM TIME KEPT: 120 days + on cooked egg yolk plus wild plankton.
MAXIMUM LENGTH REACHED: 43-50 mm.
REMARKS: On all foods except egg yolk plus wild plankton, larvae failed to survive longer than starved controls. Larvae ate yolk until 14 days after hatching, then switched to planktonic crustaceans.

JOSEPH, EDWIN B., and VISHNU P. SAK-
1966. SENA. Determination of salinity tolerances in mummichog (*Fundulus heteroclitus*) larvae obtained from hormone-induced spawning. Chesapeake Sci. 7: 193-197.

FISH STUDIED: *Fundulus heteroclitus* (L.), Cyprinodontidae.
FOOD: *Artemia* nauplii (+).
CONTAINERS: 3.8-liter (1 gal) jars.
TEMPERATURE: 22° C.

KASAHARA, SHOGORO, REIJIRO HIRANO,
1960. and YASUO OSHIMA. A study on the growth and rearing methods of black porgy, *Mylio macrocephalus* (Basilewsky). Bull. Jap. Soc. Sci. Fish. 26: 239-244. [In Japanese, with English summary.]

FISH STUDIED: *Mylio macrocephalus* (Basilewsky), Sparidae.
FOODS: *Oxyrrhis* sp. (+), *Stylonichia* sp. (+), copepod nauplii (+), *Balanus amphitrite albicostatus* nauplii (+), *Artemia* nauplii (+), young *Neomysis japonica* (+).
CONTAINERS: 2-5 liter glass aquaria, 39 liter bowl, large concrete tanks.
TEMPERATURE: 17°-25° C.
MAXIMUM TIME KEPT: 60 days +.
MAXIMUM LENGTH REACHED: 32 mm TL on day 60.
SURVIVAL: 13% at day 52.
REMARKS: Growing larvae were given progressively larger food types.

KLIMA, EDWARD F., IZADORE BARRETT,
1962. and JOHN E. KINNEAR. Artificial fertilization of the eggs, and rearing and identification of the larvae of the anchoveta, *Cetengraulis mysticetus*. Bull. Inter-Amer. Trop. Tuna Comm. 6: 155-178.

FISH STUDIED: *Cetengraulis mysticetus* (Günther), Engraulidae.
FOODS: Natural and cultured phytoplankton (?), prepared aquaria (?), *Artemia* nauplii (?), powered yolk from hard-boiled eggs (?), 12 commercially prepared fish fry foods (?), 4 water-soluble vitamin compounds (?), dry yeast microorganisms (?), human blood (?).
CONTAINERS: Various.
TEMPERATURE: 19°-23° and 26°-31° C.
MAXIMUM TIME KEPT: 154 hr.
SURVIVAL: 0.

KOTTHAUS, ADOLF. Zuchtversuche mit
1939. Heringslarven (*Clupea harengus* L.). Helgolaender wiss. Meeresunters. 1: 349-358.

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOODS: Nudibranch (? Nacktschnecken) larvae (—), *Mytilus* larvae (—), "Monadinen" (—), copepod nauplii cultured from wild plankton (+).
CONTAINERS: 165-liter earthenware pipes with circulating water; 3- to 5-liter glass jars, water changed every 3 days.
TEMPERATURE: 7.2°-9.6°, 10.0°-13.2°, and 9.3°-12.9° C.
MAXIMUM TIME KEPT: 54 days.
MAXIMUM LENGTH REACHED: 25 mm.
SURVIVAL: 4-10% after 12 days at 10.0°-13.2° C, 0.8°-1.7% after 15 days at 9.3°-12.9° C.

KOTTHAUS—Cont.

REMARKS: The only successful rearing was conducted in the 165-liter pipes with copepod nauplii as the major food; older larvae ate green algae, presumably *Enteromorpha* from the tank walls. Kotthaus refers to an unpublished report of Marx (1935) which describes the rearing of 30-40 herring larvae past the "critical stage"; some larvae attained 30 mm in 5 weeks, and of the food offered (mussel and snail larvae, copepod nauplii, and wild plankton) only nudibranch (? Nacktschnecken) larvae and copepod nauplii were found in the larval guts.

KRAMER, DAVID, and JAMES R. ZWEIFEL.
1970. Rearing and growth of anchovy larvae (*Engraulis mordax* Girard) as influenced by temperature. Calif. Coop. Oceanic Fish. Invest. Rep. 14: 84-87.

FISH STUDIED: *Engraulis mordax* Girard, Engraulidae.
FOOD: Wild plankton (+).
CONTAINER: 380-liter glass, water either not renewed or partially (10-20%) renewed daily.
TEMPERATURE: 17° and 22° C.
MAXIMUM TIME KEPT: 34 days.
MAXIMUM LENGTH REACHED: 9.8-20.7 mm SL.

KURATA, HIROSHI. On the rearing of lar-
1956. vae of the flatfish, *Liopsetta obscura*, in small aquaria. Bull. Hokkaido Reg. Fish. Res. Lab. 13: 20-29. [In Japanese, with English summary.]

FISH STUDIED: *Liopsetta obscura* (Herzenstein), Pleuronectidae.
FOODS: *Skeletonema costatum* (?), *Mytilus* larvae (+), *Artemia* nauplii (+).
CONTAINERS: 1.3-liter glass jar, one-third of water renewed once or twice daily.
TEMPERATURE: 6.8°-14.5° C.
MAXIMUM TIME KEPT: 1 year.
MAXIMUM LENGTH REACHED: 64 mm TL.
SURVIVAL: 9% at 25 days.
REMARKS: Early larvae ate larval *Mytilus* ("an excellent food for the larvae"), later switched to *Artemia* nauplii. Larvae fed *Skeletonema* survived only 1 day longer than starved controls.

KURATA, HIROSHI. Preliminary report on
1959. the rearing of the herring larvae. Bull. Hokkaido Reg. Fish. Res. Lab. 20: 117-138. [In Japanese, with English summary.]

FISH STUDIED: *Clupea pallasii* Valenciennes, Clupeidae.
FOODS: *Artemia* nauplii (+), *Chone teres* trochophores (+), *Skeletonema costatum* (?), chicken yolk (?), minced shrimp or crab meat (?).
CONTAINERS: 1.2-liter glass jars.
TEMPERATURE: 4.9°-7.7° C.
MAXIMUM TIME KEPT: 40 days +.
MAXIMUM LENGTH REACHED: 14.5 mm.
SURVIVAL: 10-20% at 40 days.
REMARKS: Only larvae fed *Artemia* nauplii survived significantly longer than starved controls. Larvae feeding for the first time took *Chone teres* trochophores in preference to *Artemia* nauplii, perhaps because of their smaller size; however, *C. teres* had the disadvantages of a short spawning season and trochophores which settled quickly.

LASKER, R., H. M. FEDER, G. H. THEI-
1970. LACKER, and R. C. MAY. Feeding, growth, and survival of *Engraulis mordax* larvae reared in the laboratory. Mar. Biol. 5: 345-353.

FISH STUDIED: *Engraulis mordax* Girard, Engraulidae.
FOODS: *Gymnodinium splendens* (+), *Prorocentrum micans* (+), *Protoceratium reticulatum* (—), *Fragilidium heterolobum* (+); veligers of *Bulla gouldiana* (+), *Haminoea vesicula* (+), and *Navanax inermis* (+); *Gymnodinium* plus veligers; *Artemia* nauplii (+).
CONTAINERS: 10-liter circular black plastic; 510-liter fiberglass.
TEMPERATURE: 16°-18° C.
MAXIMUM TIME KEPT: 50 days.
MAXIMUM LENGTH REACHED: 7.2 mm on *Gymnodinium* and 9.6 mm on *Gymnodinium* plus veligers, at day 19.

SURVIVAL: 47% on *Gymnodinium* plus *Bulla veligers*, 31% on *Gymnodinium* alone, 0 on veligers alone, at 19 days.
REMARKS: *Gymnodinium* was the only phytoplankter which gave survival better than starved controls.

LEBOUR, MARIE V. 1925. Young anglers in captivity and some of their enemies. A study in a plunger jar. J. Mar. Biol. Ass. U.K. 13: 721-734.

FISH STUDIED: *Lophius piscatorius* L., Lophiidae.
FOOD: Wild plankton (+).
CONTAINER: 50-liter plunger jar.
TEMPERATURE: 16.8°-18.8° C.
MAXIMUM TIME KEPT: 11 days.
MAXIMUM LENGTH REACHED: 7 mm.
SURVIVAL: 0.

McHUGH, J. L., and BOYD W. WALKER. 1948. Rearing marine fishes in the laboratory. Calif. Fish Game 34: 37-38.

FISHES STUDIED: *Leuresthes tenuis* (Ayres), *Atherinops affinis* (Ayres), Atherinidae.
FOODS: *Artemia* nauplii (+) in prepared aquaria.
CONTAINERS: 19-liter aquaria.
MAXIMUM TIME KEPT: 4 months +.

McMYNN, R. G., and W. S. HOAR. 1953. Effects of salinity on the development of the Pacific herring. Can. J. Zool. 31: 417-432.

FISH STUDIED: *Clupea pallasii* Valenciennes, Clupeidae.
FOODS: *Artemia* nauplii (+), *Daphnia pulex* eggs (?), liver-skim milk (?).
CONTAINERS: 600-ml beakers.
TEMPERATURE: 8°-9° C.
MAXIMUM TIME KEPT: 20 days on *Artemia*, 5 days on *Daphnia* eggs, 14 days on liver-skim milk.
MAXIMUM LENGTH REACHED: 10.2 mm TL on day 20.
SURVIVAL: 56% at day 20.

MEYER, H. A. 1878. Biologische Beobachtungen bei künstlicher Aufzucht des Herings der Westlichen Ostsee. Wiegandt, Hempel and Parey, Berlin. (Translation in Rep. U.S. Comm. Fish. 1878, Pt. 6: 629-638.)

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOOD: Wild plankton (+).
CONTAINER: 700-liter wooden tub, one-half of water renewed daily.
TEMPERATURE: 11°-20° C.
MAXIMUM TIME KEPT: 5 months.
MAXIMUM LENGTH REACHED: 65-70 mm.
REMARKS: During the first month of rearing the plankton was strained, which the author believes may have restricted larval growth and survival by eliminating certain food organisms.

MITO, SATOSHI, MASAO UKAWA, and MASAKI HIGUCHI. 1969. On the development and rearing of the larvae of a flounder, *Kareius bicoloratus* (Basilewsky) with reference to its spawning in the culturing pond. Bull. Nansei Reg. Fish. Res. Lab. 1: 87-102. [In Japanese, with English summary.]

FISH STUDIED: *Kareius bicoloratus* (Basilewsky), Pleuronectidae.
FOODS: *Brachionus plicatilis* (+), *Artemia* nauplii (+), wild plankton (+).
CONTAINERS: 40 liters, cylindrical.
TEMPERATURE: 14.2°-15.0° C.
MAXIMUM TIME KEPT: 47 days +.
MAXIMUM LENGTH REACHED: 32-33 mm TL on day 47.
SURVIVAL: 40-60% past yolk-absorption, 20-30% past metamorphosis.

MOLANDER, ARVID R., and MÄRTHA MOLANDER-SWEDMARK. 1957. Experimental investigations on variation in plaice (*Pleuronectes platessa* L.). Inst. Mar. Res., Lysekil, Ser. Biol., Rep. 7. 45 p.

FISH STUDIED: *Pleuronectes platessa* L., Pleuronectidae.
FOOD: *Artemia* nauplii (+).

MOLANDER and MOLANDER-SWEDMARK —Cont.

CONTAINERS: 5 liters, glass.
TEMPERATURE: 6°, 8°, and 10° C.
MAXIMUM TIME KEPT: 1 year +.
MAXIMUM LENGTH REACHED: 50-110 mm.
SURVIVAL: 18.6-64.2% metamorphosed.

MORRIS, ROBERT W. 1956. Some aspects of the problem of rearing marine fishes. Bull. Inst. Oceanogr. Monaco. 1082. 61 p.

FISHES STUDIED: A total of 17 spp. were investigated. Of these, 5 spp. were reared through metamorphosis (identified below by **) and 5 spp. well beyond yolk absorption (identified below by *): *Clupea pallasii* Valenciennes, *Sardinops sajax* (Jenyns), Clupeidae; *Engraulis mordax* Girard, Engraulidae; *Spirinchus starksi* (Fisk)*, Osmeridae; *Aulorhynchus flavidus* Gill**, Aulorhynchidae; *Genyonemus lineatus* (Ayres)*, Sciaenidae; *Oxyjulis californica* (Günther), Labridae; *Sebastes goodei* (Eigenmann and Eigenmann)*, *Sebastolobus* sp., Scorpaenidae; *Hexagrammos* sp., Hexagrammidae; *Clinocottus recalvus* (Greeley)**, *Oligocottus snyderi* Greeley**, *Clinocottus analis* (Girard), *Scorpaenichthys marmoratus* (Ayres), Cottidae; *Leuresthes tenuis* (Ayres)**, *Atherinopsis californiensis* Girard**, Atherinidae; *Citharichthys* sp., Bothidae.
FOODS: Wild plankton (+), *Mytilus californianus "larvae"* (+), *Tigriopus fulvus* (+), *Artemia* nauplii (+), *Balanus glandula* nauplii (+), *Dendraster excentricus* "eggs and larvae" (+), *Strongylocentrotus purpuratus* "eggs and larvae" (+), *Oxyrrhis marina* (—), *Stichococcus* sp. (?), *Dunaliella* sp. (—), yeast (?), cooked chicken egg yolk (?).
CONTAINERS: 28-liter glass jars with rotating discs, water renewed periodically.
TEMPERATURE: Various, within the range 8°-22° C.
MAXIMUM TIME KEPT: 5 spp. through metamorphosis, 5 spp. well beyond yolk absorption.
SURVIVAL: 10-70%, among fish which had metamorphosed.
REMARKS: Successful rearing attempts employed *Artemia* nauplii as food for early larvae and adult *Tigriopus* for older larvae. *Genyonemus* was reared well past yolk absorption using *Dendraster* eggs and, later, *Artemia* nauplii as food. In all rearing attempts the main food was supplemented by "secondary foods," defined by the author as "items which are too small to be directly fed upon by the fish larvae but which are incidentally ingested"; these items apparently also served as nourishment for some of the main food organisms and included *Stichococcus, Dunaliella,* cooked egg yolk, and yeast.

NIKITINSKAYA, I. V. 1958. On the onset of active feeding of the larvae of *Clupea harengus pallasi* Val. Zool. Zh. 37: 1568-1571. [In Russian, with English summary.]

FISH STUDIED: *Clupea palasii* Valenciennes, Clupeidae.
FOOD: Cooked egg yolk (+).
MAXIMUM TIME KEPT: 18-20 days after yolk-absorption.
REMARKS: A higher food concentration was needed for first-feeding larvae than for larvae at later stages. Author states that in the laboratory the food concentration must be 50 times greater than in nature.

OKAMOTO, RYO. 1969. Rearing of red sea bream larvae. Symposium on Culture and Propagation of Sea Breams. Bull. Jap. Soc. Sci. Fish. 35: 563-566, 603. [In Japanese, with English summary.]

FISH STUDIED: *Pagrus major* (Temminck and Schlegel), Sparidae.
FOODS: Oyster and mussel trochophores (+), *Brachionus plicatilis* (+), *Artemia* nauplii (+), wild plankton (+).
CONTAINERS: 30 liters.
MAXIMUM LENGTH REACHED: 39 mm TL at day 45.
SURVIVAL: At 20 days, usually 10-20%, maximally 55.6%.
REMARKS: Growing larvae were given progressively larger food types.

ORCUTT, HAROLD GEORGE. The life history of the starry flounder, *Platichthys stellatus* (Pallas). Calif. Dep. Fish Game, Fish Bull. 78. 64 p.
1950.

FISH STUDIED: *Platichthys stellatus* (Pallas), Pleuronectidae.
FOODS: *Tigriopus fulvus* nauplii (—), *Artemia* nauplii (—), *Strongylocentrotus purpuratus* motile blastulae (—), *Platymonas subcordiformis* (+), *Nitzschia closterium* (—), wild plankton (—).
CONTAINERS: 3.8-liter glass jars.
TEMPERATURE: 12.5° C.
MAXIMUM TIME KEPT: 10 days.
MAXIMUM LENGTH REACHED: 3.5 mm TL on day 4.
SURVIVAL: 0.
REMARKS: Larvae which ingested *Platymonas* appeared to be starving.

QASIM, S. Z. Rearing experiments on marine teleost larvae and evidence of their need for sleep. Nature (London) 175: 217-218.
1955.

Laboratory experiments on some factors affecting the survival of marine teleost larvae. J. Mar. Biol. Ass. India 1: 13-25.
1959.

FISHES STUDIED: *Blennius pholis* L., *Centronotus gunnellus* (L.), Blenniidae.
FOODS: *Chromulina pusilla* (+), *Isochrysis galbana* (+), *Chlamydomonas* sp. (+), *Chlorella stigmata* (+), *Prorocentrum micans* (+), *Artemia* nauplii (+), barnacle nauplii (+).
CONTAINERS: 25-liter glass jars.
MAXIMUM TIME KEPT: 68 days +.
SURVIVAL: "A small percentage" passed metamorphosis.
REMARKS: The two papers seem to describe the same experiments. Larvae fed only phytoplankters did not survive significantly longer than starved controls. Nauplii plus phytoplankters gave no better survival than nauplii alone.

RICHARDS, WILLIAM J., and BARBARA J. PALKO. Methods used to rear the thread herring, *Opisthonema oglinum*, from fertilized eggs. Trans. Amer. Fish. Soc. 98: 527-529.
1969.

FISH STUDIED: *Opisthonema oglinum* (LeSueur), Clupeidae.
FOODS: Wild plankton (?), *Tripneustes esculentus* eggs (?), finely ground trout food (?), *Artemia* nauplii (?).
CONTAINERS: 38-liter glass aquaria, water partially renewed every 2 or 3 days.
TEMPERATURE: Approximately 21°-33° C.
MAXIMUM TIME KEPT: 95 days.
MAXIMUM LENGTH REACHED: 34-53 mm SL.
SURVIVAL: ca. 0.8% at day 95.
REMARKS: Tanks had a high concentration of *Chlorella* as food for plankton; authors had no evidence that fish larvae fed on *Chlorella.*

ROLLEFSEN, GUNNAR. Artificial rearing of the fry of sea water fish. Preliminary communication. Cons. Perma. Int. Explor. Mer, Rapp. Proc.-Verb. Réun. 109, Pt. 3: 133.
1939.

FISH STUDIED: *Pleuronectes platessa* L., Pleuronectidae.
FOOD: *Artemia* nauplii (+).
CONTAINERS: 200-liter tanks, petri dishes.
TEMPERATURE: 10° C.
MAXIMUM TIME KEPT: Past metamorphosis.
SURVIVAL: 50-75% "rearing percentage."
REMARKS: Rollefsen's 1940 paper (Naturen 6-7: 197-217; in Norwegian) contains roughly the same experimental results for plaice rearing as his 1939 paper—the survival is given as 70% (to metamorphosis ?).

RUBINOFF, IRA. Raising the atherinid fish *Menidia menidia* in the laboratory. Copeia 1958: 146-147.
1958.

FISH STUDIED: *Menidia menidia* (L.), Atherinidae.
FOODS: *Arbacia* larvae (?), *Crepidula* larvae (?), "diatoms" (?), powdered fish foods (?), *Artemia* nauplii (+).
CONTAINER: 25-liter wooden trough, circulating water.
TEMPERATURE: 22° C.
MAXIMUM TIME KEPT: 48 days.
MAXIMUM LENGTH REACHED: 27-30 mm.

RUNNSTRÖM, SVEN. Quantitative investi-
1941. gations on herring spawning and its yearly fluctuations at the west coast of Norway. Fiskeridir. Skr., Ser. Havunders. 6(8). 71 p.

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOOD: "Plankton algae" (+).
REMARKS: The author makes only the following brief mention of his rearing attempt: "By hatching experiments with herring eggs I succeeded to keep the free-swimming larvae alive for 6 weeks without any great mortality, feeding them on plankton algae. Always, however, when they had reached a certain stage, they all died in a short time (p. 34)."

SCHACH, HELMUT. Die künstliche Auf-
1939. zucht von *Clupea harengus* L. Helgolaender wiss. Meeresunters. 1: 359-372.

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOODS: Wild plankton (+), *Mytilus* trochophores (?).
CONTAINERS: 190- to 2500-liter tile and stoneware, circulating or static water.
TEMPERATURE: 10.5° C.
MAXIMUM TIME KEPT: 56 days.
MAXIMUM LENGTH REACHED: 20-60 mm.
SURVIVAL: 7% at day 56.
REMARKS: Food was held in a special container with a large crop of phytoplankton, from which it was siphoned into the rearing container; larvae probably ingested the phytoplankton as well as zooplankton.

SHELBOURNE, J. E. The artificial propa-
1964. gation of marine fish. Advan. Mar. Biol. 2: 1-83.

FISH STUDIED: *Pleuronectes platessa* L., Pleuronectidae.
FOOD: *Artemia* nauplii (+).
CONTAINERS: 40-liter glass, slowly circulating water.
TEMPERATURE: 7°-11° C.
MAXIMUM TIME KEPT: 100 days.
SURVIVAL: Maximum of 66% of original eggs passed metamorphosis.
REMARKS: In some earlier experiments the author used *Balanus balanoides* nauplii as a first food. This paper summarizes several earlier papers on plaice rearing by the author and his coworkers and reviews the history of marine fish culture.

SHIOKAWA, TSUKASA, and HIROSHI TSU-
1961. KAHARA. Studies in habits of coastal fishes in the Amakusa Islands. Part 1. Early life history of the purple rockfish, *Sebastes pachycephalus pachycephalus* Temminck et Schlegel. Rec. Oceanogr. Works Jap., Spec. No. 5: 123-127.

FISH STUDIED: *Sebastes pachycephalus pachycephalus* Temminck and Schlegel, Scorpaenidae.
FOOD: *Artemia* nauplii (+).
TEMPERATURE: 15° C.
MAXIMUM TIME KEPT: 25 days (+?).
MAXIMUM LENGTH REACHED: 13 mm TL at 25 days.

SHOJIMA, YOICHI. On the development of
1957. eggs and rearing of larvae of a puffer, *Fugu* (*Higanfugu*) *pardalis* (T. and S.). Sci. Bull. Fac. Agr. Kyushu Univ. 16: 125-136. [In Japanese, with English summary.]

FISH STUDIED: *Fugu* (*Higanfugu*) *pardalis* (Temminck and Schlegel), Tetraodontidae.
FOOD: *Artemia* nauplii (+).
CONTAINERS: Glass jars.
TEMPERATURE: 11°-17° C.
MAXIMUM TIME KEPT: 50 days.
MAXIMUM LENGTH REACHED: 13.09 mm TL.
SURVIVAL: 5-15% at 3 weeks.

SOLEIM, PEDER A. Årsaker til rike og fat-
1942. tige årganger av sild. Fiskeridir. Skr., Ser. Havunders. 7(2). 39 p.

FISH STUDIED: *Clupea harengus* L., Clupeidae.
FOODS: Nauplii of *Artemia* and *Balanus balanoides* (+), "vegetarian diet" (?).
CONTAINERS: 7-14 liters.
TEMPERATURE: 10°-15° C.
MAXIMUM TIME KEPT: 2 months.
MAXIMUM LENGTH REACHED: 18 mm.

REMARKS: Author states that " . . . a vegetarian diet alone was unable to keep the larvae alive in early life." In an earlier paper (Fiskeridir. Skr. 6(4): 39-55, 1940) the author reported a 50% mortality of larvae at the time of yolk absorption, at 14° C.

TSUKAHARA, HIROSHI. 1962. Studies on habits of coastal fishes in the Amakusa Islands. Part 2. Early life history of the rockfish, *Sebastiscus marmoratus* (Cuvier et Valenciennes). Rec. Oceanogr. Works Jap., Spec. No. 6: 49-55.

FISH STUDIED: *Sebastiscus marmoratus* (Cuvier and Valenciennes), Scorpaenidae.
FOOD: *Artemia* nauplii (—).
TEMPERATURE: 15° C.
MAXIMUM TIME KEPT: 10 days.
MAXIMUM LENGTH REACHED: 5 mm TL.
REMARKS: *Artemia* nauplii were "too large to be swallowed."

TSUKAHARA, HIROSHI, and TSUKASA SHIOKAWA. 1957. Studies on the flying-fishes of the Amakusa Islands. Part 2. The life history and habits of *Parexocoetus mento* (Cuvier et Valenciennes). Sci. Bull. Fac. Agr. Kyushu Univ. 16: 275-286. [In Japanese, with English summary.]

FISH STUDIED: *Parexocoetus mento* (Cuvier and Valenciennes), Exocoetidae.
FOOD: *Artemia* nauplii (+).

TSUKAHARA, HIROSHI, TSUKASA SHIOKAWA, and TADASHI INAO. 1957. Studies on the flying-fishes of the Amakusa Islands. Parts 3 and 4. The life histories and habits of three species of the genus *Cypselurus*. Sci. Bull. Fac. Agr. Kyushu Univ. 16: 287-311. [In Japanese, with English summary.]

FISHES STUDIED: *Cypselurus opisthopus hiraii* Abe, *Cypselurus heterurus döderleini* Abe, *Cypselurus starksi* Abe, Exocoetidae.
FOOD: *Artemia* nauplii (+).

YAMAMOTO, GOTARO, and CHUZO NISHIOKA. 1952. The development and rearing of hatched larvae of North Pacific cod (*Gadus macrocephalus* Tilesius). Spec. Publ. Jap. Sea Reg. Fish. Res. Lab., on the third anniversary of its founding: 301-308. [Translation No. 402, Fish. Res. Bd. Can.]

FISH STUDIED: *Gadus macrocephalus* Tilesius, Gadidae.
FOOD: Wild plankton (+).
CONTAINERS: Glass bowls, 20-30 cm diameter; circulating water, or static water changed daily.
TEMPERATURE: 3°-6° C (?).
MAXIMUM TIME KEPT: 28 days in static water.
REMARKS: Larvae ate small crustaceans and larval molluscs, along with a few diatoms. Results from experiments conducted with running water were unsatisfactory.

APPENDIX I

Species of Marine Fishes Used in Laboratory Rearing Attempts.

Fish	References
CLUPEIDAE (herrings)	
Alosa sp.	Fabre-Domergue and Biétrix, 1897
Alosa pseudoharengus (Wilson)	Fahey, 1964
Clupea harengus L.	Bishai, 1961; Blaxter, 1962, 1968; Blaxter and Hempel, 1961; Bückman et al., 1953; A. Dannevig, 1948; Dannevig and Hansen, 1952; Fabre-Domergue and Biétrix, 1897; Gross, 1937; Kotthaus, 1939; Meyer, 1878; Runnström, 1941; Schach, 1939; Soleim, 1942
Clupea pallasii Valenciennes	Ivanchenko and Ivanchenko, 1969; Kurata, 1959; McMynn and Hoar, 1953; Morris, 1956; Nikitinskaya, 1958
Opisthonema oglinum (LeSueur)	Richards and Palko, 1969
Sardina pilchardus (Walbaum)	Blaxter, 1969; Cunningham, 1893-95a; Gross, 1937
Sardinops sajax (Jenyns)	Morris, 1956
ENGRAULIDAE (anchovies)	
Cetengraulis mysticetus (Günther)	Klima et al., 1962
Engraulis mordax Girard	Kramer and Zweifel, 1970; Lasker et al., 1970; Morris, 1956
OSMERIDAE (smelts)	
Spirinchus starksi (Fisk)	Morris, 1956
EXOCOETIDAE (flyingfishes)	
Cypselurus heterurus döderleini Abe	Tsukahara et al., 1957
Cypselurus opisthopus hiraii Abe	Tsukahara et al., 1957
Cypselurus starksi Abe	Tsukahara et al., 1957
Parexocoetus mento (Cuvier and Valenciennes)	Tsukahara and Shiokawa, 1957
CYPRINODONTIDAE (killifishes)	
Fundulus heteroclitus (L.)	Joseph and Saksena, 1966
Fundulus majalis (Walbaum)	Fahey, 1964
GADIDAE (codfishes and hakes)	
Gadus macrocephalus Tilesius	Forrester, 1964; Yamamoto and Nishioka, 1952
Gadus merlangus L.	Cunningham, 1893-95b
Gadus morhua L.	Dannevig and Hansen, 1952
GASTEROSTEIDAE (sticklebacks)	
Gasterosteus aculeatus L.	Heuts, 1947
AULORHYNCHIDAE (tube-snouts)	
Aulorhynchus flavidus Gill	Morris, 1956

Appendix I—Species of marine fishes used in laboratory rearing attempts—Cont.

Fish	References
POMATOMIDAE (bluefishes)	
Pomatomus saltatrix (L.)	Deuel et al., 1966
SCIAENIDAE (drums)	
Bairdiella chrysura (Lacépède)	Fahey, 1964
Genyonemus lineatus (Ayres)	Morris, 1956
SPARIDAE (porgies)	
Mylio macrocephalus (Basilewsky)	Hirano, 1969; Kasahara et al., 1960
Pagrus major (Temminck and Schlegel)	Okamoto, 1969
LABRIDAE (wrasses)	
Oxyjulis californica (Günther)	Morris, 1956
TRACHINIDAE (weevers)	
Trachinus sp.	Fabre-Domergue and Biétrix, 1897
SCOMBRIDAE (mackerels and tunas)	
Scomber japonicus Houttuyn	Schumann, in Bardach, 1968
Scomber scombrus L.	A. Dannevig, 1948; Fabre-Domergue and Biétrix, 1897
GOBIIDAE (gobies)	
Bathygobius andrei (Sauvage)	Delmonte et al., 1968
Lophogobius cyprinoides (Pallas)	Delmonte et al., 1968
Luciogobius sakaiensis Dôtu	Dôtu and Mito, 1958
SCORPAENIDAE (scorpionfishes and rockfishes)	
Sebastes oblongus Günther	Fujita, 1958
Sebastes pachycephalus nigricans (Schmidt)	Fujita, 1957
Sebastes pachycephalus pachycephalus Temminck and Schlegel	Shiokawa and Tsukahara, 1961
Sebastiscus marmoratus (Cuvier and Valenciennes)	Tsukahara, 1962
Sebastes goodei (Eigenmann and Eigenmann)	Morris, 1956
Sebastolobus sp.	Morris, 1956
HEXAGRAMMIDAE (greenlings)	
Hexagrammos sp.	Morris, 1956
COTTIDAE (sculpins)	
Clinocottus analis (Girard)	Budd, 1940; Morris, 1956
Clinocottus recalvus (Greeley)	Morris, 1956
Oligocottus snyderi Greeley	Morris, 1956
Scorpaenichthys marmoratus (Ayres)	Morris, 1956
Taurulus bubalis (Euphrasen)	Fabre-Domergue and Biétrix, 1897

Appendix I—Species of marine fishes used in laboratory rearing attempts—Cont.

Fish	References
AGONIDAE (poachers and alligatorfishes)	
Agonus cataphractus L.	Hertling, 1932
BLENNIIDAE (combtooth blennies)	
Blennius pavo Risso	Fishelson, 1963
Blennius pholis L.	Qasim, 1955, 1959
Blennius ocellaris L.	Garstang, 1900
Centronotus gunnellus (L.)	Qasim, 1955, 1959
STICHAEIDAE (pricklebacks)	
Ernogrammus hexagrammus (Temminck and Schlegel)	Fujita and Uchida, 1959
MUGILIDAE (mullets)	
Mugil cephalus L.	Fahey, 1964
ATHERINIDAE (silversides)	
Atherina presbyter Valenciennes	Fabre-Domergue and Biétrix, 1897
Atherinops affinis (Ayres)	McHugh and Walker, 1948
Atherinopsis californiensis Girard	Morris, 1956
Leuresthes tenuis (Ayres)	David, 1939; McHugh and Walker, 1948; Morris, 1956
Menidia menidia (L.)	Rubinoff, 1958
Odontesthes (Austromenidia) regia regia (Humboldt)	Chironos de Vildoso and Chuman, 1964
BOTHIDAE (lefteye flounders)	
Citharichthys sp.	Morris, 1956
Scophthalmus maximus (L.)	Anthony, 1910
PLEURONECTIDAE (righteye flounders)	
Eopsetta grigorjewi (Herzenstein)	Fujita, 1965
Kareius bicoloratus Basilewsky	Mito et al., 1969
Liopsetta obscura (Herzenstein)	Kurata, 1956
Microstomus kitt (Walbaum)	A. Dannevig, 1948
Parophrys vetulus Girard	Budd, 1940
Platichthys stellatus (Pallas)	Orcutt, 1950
Pleuronectes platessa L.	Cunningham, 1893-95b; H. Dannevig, 1897; Dannevig and Hansen, 1952; Molander and Molander-Swedmark, 1957; Rollefsen, 1939; Shelbourne, 1964
Pleuronichthys coenosus Girard	Budd, 1940
Pleuronichthys decurrens Jordan and Gilbert	Budd, 1940
Pleuronichthys verticalis Jordan and Gilbert	Budd, 1940
Tanakius kitaharai (Jordan and Starks)	Fujita, 1965

Appendix I—Species of marine fishes used in laboratory rearing attempts—Cont.

Fish	References
SOLEIDAE (soles)	
Solea solea (L.)	A. Dannevig, 1948; Fabre-Domergue and Biétrix, 1905; Flüchter, 1965
TETRAODONTIDAE (puffers)	
Fugu (*Higanfugu*) *pardalis* (Temminck and Schlegel)	Shojima, 1957
Lagocephalus lunaris spadiceus (Richardson)	Fujita, 1966
LOPHIIDAE (anglers)	
Lophius piscatorius L.	Gross, 1937; Lebour, 1925

APPENDIX II

Foods Used in Attempts to Rear the Larvae of Marine Fishes.[1]

Food	References
WILD PLANKTON	
	Anthony, 1910; Blaxter, 1968, 1969; Blaxter and Hempel, 1961; Budd, 1940; Cunningham, 1893-95a & b; A. Dannevig, 1948; H. Dannevig, 1897; Dannevig and Hansen, 1952; David, 1939; Dôtu and Mito, 1958; Fabre-Domergue and Biétrix, 1897, 1905; Garstang, 1900; Ivanchenko and Ivanchenko, 1969; Kramer and Zweifel, 1970; Lebour, 1925; Meyer, 1878; Mito et al., 1969; Morris, 1956; Okamoto, 1969; Orcutt, 1950; Richards and Palko, 1969; Schach, 1939; Schumann, in Bardach, 1968; Yamamoto and Nishioka, 1952
PROTISTA: PLANKTONIC FORMS	
Chlorophyta:	
Loxophyceae:	
Platymonas subcordiformis	Orcutt, 1950
Halosphaera minor	Blaxter, 1969
Chlorophyceae:	
Chlamydomonas sp.	Bishai, 1961; Blaxter, 1962, 1969; Gross, 1937; Qasim, 1955, 1959
Dunaliella primolecta	Blaxter, 1969
Dunaliella salina	Fabre-Domergue and Biétrix, 1905
Dunaliella sp.	Blaxter, 1962; Budd, 1940; Delmonte et al., 1968; Morris, 1956
Chlorella stigmata	Qasim, 1955
Chlorella sp.	Blaxter, 1962
Stichococcus sp.	Morris, 1956
Pyrrophyta:	
Cryptophyceae:	
Cryptomonas maculata	Blaxter, 1969
Desmophyceae:	
Prorocentrum micans	Blaxter, 1969; Gross, 1937, Lasker et al., 1970; Qasim, 1955
Dinophyceae:	
Gymnodinium splendens	Lasker et al., 1970
Oxyrrhis marina	Morris, 1956
Oxyrrhis sp.	Kasahara et al., 1960
Protoceratium reticulatum	Lasker et al., 1970
Fragilidium heterolobum	Lasker et al., 1970
Crysophyta:	
Xanthophyceae:	
Olisthodiscus sp.	Blaxter, 1969

[1] See footnote at end of table.

Appendix II—Foods used in attempts to rear the larvae of marine fishes—Cont.

Food	References
Chrysophyceae:	
Isochrysis galbana	Qasim, 1955, 1959
Monochrysis lutheri	Forrester, 1964
Chromulina pusilla	Qasim, 1955
Bacillariophyceae:	
Coscinodiscus concinnus	Hertling, 1932
Coscinodiscus radiatus	Gross, 1937
Skeletonema costatum	Blaxter, 1962; Forrester, 1964; Gross, 1937; Kurata, 1956, 1959
Thalassiosira sp.	Gross, 1937
Lauderia borealis	Blaxter, 1969
Rhizosolenia sp.	David, 1939
Chaetoceros sp.	David, 1939
Biddulphia mobiliensis	Hertling, 1932
Ditylum brightwellii	Blaxter, 1969
Nitzschia closterium	Orcutt, 1950
Nitzschia sp.	Bishai, 1961; Blaxter, 1962; Budd, 1940
"Diatoms"	David, 1939; Rubinoff, 1958
Eumycophyta:	
Ascomycetes:	
"Yeast"	Klima et al., 1962; Morris, 1956
Taxonomy uncertain:	
"Natural and cultured phytoplankton"	Klima et al., 1962
"Raw cultures of phytoplankton"	Dannevig, 1948
"Cultures of single species of green algae and naked flagellates"	Dannevig, 1948
"Phytoplankton"	Bishai, 1961; Ivanchenko and Ivanchenko, 1969
"Plankton algae"	Runnström, 1941
"Algae"	Fabre-Domergue and Biétrix, 1897
"Monadinen"	Kotthaus, 1939
"Vegetarian diet"	Soleim, 1942
PROTISTA: NONPLANKTONIC FORMS	
Cyanophyta:	
"Blue-green algae"	Fabre-Domergue and Biétrix, 1897
Chlorophyta:	
Enteromorpha sp.	Kotthaus, 1939
Chrysophyta:	
"Filamentous brown diatom"	Fabre-Domergue and Biétrix, 1897
Ciliophora:	
Ciliata:	
Euplotes sp.	Fabre-Domergue and Biétrix, 1897
Philaster digitiformis	Fabre-Domergue and Biétrix, 1897
Stylonychia sp.	Kasahara et al., 1960
Taxonomy uncertain:	
"Filamentous algae"	Delmonte et al., 1968
"Cultured infusorians"	Fabre-Domergue and Biétrix, 1897

Appendix II—Foods used in attempts to rear the larvae of marine fishes—Cont.

Food	References
METAZOA: PLANKTONIC FORMS	
Aschelminthes:	
Rotifera:	
Brachinous plicatilis	Hirano, 1969; Mito et al., 1969; Okamoto, 1969
Mollusca:	
Gastropoda:	
Crepidula sp. "larvae"	Rubinoff, 1958
Bulla gouldiana veligers	Lasker et al., 1970
Haminoea vesicula veligers	Lasker et al., 1970
Navanax inermis veligers	Lasker et al., 1970
"Nacktschnecken" (? nudibranch) larvae	Kotthaus, 1939
Pelecypoda:	
Mytilus californianus "larvae"	Morris, 1956
Mytilus sp. trochophores	Blaxter and Hempel, 1961; Okamoto, 1969; Schach, 1939
Mytilus sp. "larvae"	Dannevig, 1948; Kotthaus, 1939; Kurata, 1956
Ostrea edulis "larvae"	Dannevig, 1948
Crassostrea gigas "larvae"	Hirano, 1969
"Oyster" trochophores	Okamoto, 1969
Annelida:	
Polychaeta:	
Chone teres trochophores	Kurata, 1959
Pomatoceros sp. "larvae"	Dannevig, 1948
Nereis sp. eggs	Cunningham, 1893-95b
"Minced worms"	Cunningham, 1893-95a
Arthropoda:	
Crustacea:	
Artemia salina nauplii	Bishai, 1961; Blaxter, 1962, 1968; Blaxter and Hempel, 1961; Budd, 1940; Chirinos de Vildoso, 1964; Dannevig, 1948; Dannevig and Hansen, 1953; Delmonte et al., 1968; Fahey, 1964; Fishelson, 1963; Flüchter, 1965; Forrester, 1964; Fujita, 1957, 1958, 1965, 1966; Fujita and Uchida, 1959; Gross, 1937; Hirano, 1969; Joseph and Saksena, 1966; Kasahara et al., 1960; Klima et al., 1962; Kramer and Zweifel, 1970; Kurata, 1956, 1959; McHugh and Walker, 1948; McMynn and Hoar, 1953; Mito et al., 1969; Molander and Molander-Swedmark, 1957; Morris, 1956; Okamoto, 1969; Orcott, 1950; Qasim, 1955, 1959; Richards and Palko, 1969; Rollefsen, 1939; Rubinoff, 1958; Schumann, in Bardach, 1968; Shelbourne, 1964; Shiokawa and Tsukahara, 1961; Shojima, 1957; Soleim, 1942; Tsukahara, 1962; Tsukahara and Shiokawa, 1957; Tsukahara et al., 1957
Cladocera	Gross, 1937

Appendix II—Foods used in attempts to rear the larvae of marine fishes—Cont.

Food	References
Arthropoda—Cont.	
Crustacea—Cont.	
Daphnia pulex eggs	McMynn and Hoar, 1953
Daphnia sp.	Bückmann et al., 1953
Copepods	Bishai, 1961; Bückmann et al., 1953; Fishelson, 1963; Gross, 1937; Hirano, 1969
Copepod nauplii	Kasahara et al., 1960; Kotthaus, 1939
Tigriopus californicus nauplii	Fahey, 1964
Tigriopus fulvus nauplii	Bishai, 1961; Budd, 1940; Orcutt, 1950
Tigriopus fulvus adults	Blaxter, 1965, 1968; Morris, 1956
Tigriopus sp. "young stages"	Blaxter, 1962
Tisbe sp.	Blaxter, 1962
Balanus balanoides nauplii	Blaxter, 1962, 1968; Dannevig, 1948; Qasim, 1955, 1959; Shelbourne, 1964; Soleim, 1942
Balanus glandula nauplii	Morris, 1956
Balanus amphitrite albicostatus nauplii	Hirano, 1969; Kasahara et al., 1960
Neomysis japonicus "young"	Kasahara et al., 1960
Echinodermata:	
Echinoidea:	
Dendraster excentricus eggs or larvae	Morris, 1956
Strongylocentrotus purpuratus eggs or larvae	Budd, 1940; Morris, 1956; Orcutt, 1950
Tripneustes esculentus eggs or larvae	Richards and Palko, 1969
Arbacia sp. eggs or larvae	Deuel et al., 1966; Rubinoff, 1958
"Fertilized sea urchin eggs"	Fujita, 1965
Asteroidea:	
Asterias sp. eggs	Blaxter, 1962
Urochordata:	
Ascidian larvae	Fabre-Domergue and Biétrix, 1897
Chordata:	
Fish larvae	Fabre-Domergue and Biétrix, 1905
METAZOA: NONPLANKTONIC FORMS	
Aschelminthes:	
Nematoda:	
Anguillicula sp.	Blaxter, 1962
MISCELLANEOUS	
Prepared aquaria	Bishai, 1961; Delmonte et al., 1968; Heuts, 1947; Klima et al., 1962; McHugh and Walker, 1948
Finely ground trout food	Richards and Palko, 1969
Powdered fish foods	Rubinoff, 1958
Commercial fish-fry foods	Blaxter, 1962; Delmonte et al., 1968; Klima et al., 1962

Appendix II—Foods used in attempts to rear the larvae of marine fishes—Cont.

Food	References
MISCELLANEOUS—Cont.	
Cooked chicken egg yolk	Bückmann et al., 1953; Fabre-Domergue and Biétrix, 1897; Fishelson, 1963; Fujita, 1966; Heuts, 1947; Ivanchenko and Ivanchenko, 1969; Klima et al., 1962; Kurata, 1959; Morris, 1956; Nikitinskaya, 1958
Water-soluble vitamin compounds	Klima et al., 1962
Liver of shore crab, *Carcinus maenus*	Bishai, 1961
Minced shrimp and crab meat	Kurata, 1959
Crushed mussel	Fabre-Domergue and Biétrix, 1897
Homogenates of *Mytilus*, periwinkle, *Fucus* and kelp	Ivanchenko and Ivanchenko, 1969
Liver-skim milk	McMynn and Hoar, 1953
Human blood	Klima et al., 1962

[1] This table is taken, with some additions, from: May, R. C. 1970. Calif. Coop. Oceanic Fish. Invest. Rep. 14: 76-83.

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salmon (models I and II), by Daniel W. Bates and John G. Vanderwalker, pp. 1-5, 6 figs., 1 table; 2d paper, Design and operation of a cantilevered traveling fish screen (model V), by Daniel W. Bates, Ernest W. Murphey, and Earl F. Prentice, 10 figs., 1 table.

609. Annotated bibliography of zooplankton sampling devices. By Jack W. Jossi. July 1970, iii + 90 pp.

610. Limnological study of lower Columbia River, 1967-68. By Shirley M. Clark and George R. Snyder. July 1970, iii + 14 pp., 15 figs., 11 tables.

611. Laboratory tests of an electrical barrier for controlling predation by northern squawfish. By Galen H. Maxfield, Robert H. Lander, and Charles D. Volz. July 1970, iii + 8 pp., 4 figs., 5 tables.

612. The Trade Wind Zone Oceanography Pilot Study. Part VIII: Sea-level meteorological properties and heat exchange processes, July 1963 to June 1965. By Gunter R. Seckel. June 1970, iv + 129 pp., 6 figs., 8 tables.

613. Sea-bottom photographs and macrobenthos collections from the Continental Shelf off Massachusetts. By Roland L. Wigley and Roger B. Theroux. August 1970, iii + 12 pp., 8 figs., 2 tables.

614. A sled-mounted suction sampler for benthic organisms. By Donald M. Allen and J. Harold Hudson. August 1970, iii + 5 pp., 5 figs., 1 table.

615. Distribution of fishing effort and catches of skipjack tuna, *Katsuwonus pelamis*, in Hawaiian waters, by quarters of the year, 1948-65. By Richard N. Uchida. June 1970, iv + 37 pp., 6 figs., 22 tables.

616. Effect of quality of the spawning bed on growth and development of pink salmon embryos and alevins. By Ralph A. Wells and William J. McNeil. August 1970, iii + 6 pp., 4 tables.

617. Fur seal investigations, 1968. By NMFS, Marine Mammal Biological Laboratory. December 1970, iii + 69 pp., 68 tables.

618. Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River Basin - past and present. By Leonard A. Fulton. December 1970, iii + 37 pp., 6 figs., 11 maps, 9 tables.

619. Macrozooplankton and small nekton in the coastal waters off Vancouver Island (Canada) and Washington, spring and fall of 1963. By Donald S. Day, January 1971, iii + 94 pp., 19 figs., 13 tables.

620. The Trade Wind Zone Oceanography Pilot Study. Part IX: The sea-level wind field and wind stress values, July 1963 to June 1965. By Gunter R. Seckel. June 1970, iii + 66 pp., 5 figs.

621. Predation by sculpins on fall chinook salmon, *Oncorhynchus tshawytscha*, fry of hatchery origin. By Benjamin G. Patten. February 1971, iii + 14 pp., 6 figs., 9 tables.

622. Number and lengths, by season, of fishes caught with an otter trawl near Woods Hole, Massachusetts, September 1961 to December 1962. By F. E. Lux and F. E. Nichy. February 1971, iii + 15 pp., 3 figs., 19 tables.

623. Apparent abundance, distribution, and migrations of albacore, *Thunnus alalunga*, on the North Pacific longline grounds. By Brian J. Rothschild and Marian Y. Y. Yong. September 1970, v + 37 pp., 19 figs., 5 tables.

624. Influence of mechanical processing on the quality and yield of bay scallop meats. By N. B. Webb and F. B. Thomas. April 1971, iii + 11 pp., 9 figs., 3 tables.

625. Distribution of salmon and related oceanographic features in the North Pacific Ocean, spring 1968. By Robert R. French, Richard G. Bakkala, Masanao Osako, and Jun Ito. March 1971, iii + 22 pp., 19 figs., 3 tables.

626. Commercial fishery and biology of the freshwater shrimp, *Macrobrachium*, in the Lower St. Paul River, Liberia, 1952-53. By George C. Miller. February 1971, iii + 13 pp., 8 figs., 7 tables.

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